Food and Agriculture Organization of the United Nations

Forests, trees and wild species in agrifood systems

Optimizing benefits for biodiversity, climate and health

PEOPLE & PLANTS

Alliance Bioversity & CIAT

CGIAR

SHOUT
SHARE
IT

Forests, trees and wild species in agrifood systems

Optimizing benefits for biodiversity, climate and health

Sarah Laird, Giulia Muir, Patricia Shanley, Alan Pierce,
Citlalli López Binnquist, Jenne de Beer, Barbara Vinceti and Sven Walter

Food and Agriculture Organization of the United Nations. 2024, Rome

Required citation:
Laird, S., Muir, G., Shanley, P., Pierce, A., López Binnquist, C., de Beer, J., Vinceti, B. & Walter, S. 2024. *Forests, trees and wild species in agrifood systems – Optimizing benefits for biodiversity, climate and health.* Rome, FAO. https://doi.org/10.4060/cd2883en

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

ISBN 978-92-5-139226-3
© FAO, 2024

Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons licence. If a translation of this work is created, it must include the following disclaimer along with the required citation: "This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original [Language] edition shall be the authoritative edition."

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization http://www.wipo.int/amc/en/mediation/rules and any arbitration will be conducted in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org. Requests for commercial use should be submitted via: www.fao.org/contact-us/licence-request. Queries regarding rights and licensing should be submitted to: copyright@fao.org.

Cover photograph:
Madagascar. Centella picker with freshly collected leaves
© UEBT

© Shutterstock

CONTENTS

Table of contents	iii
Acknowledgements	iv
Key messages	1
Wild and forest foods at a glance	2
Introduction	3
Forest foods, wild species and agrifood systems - Key terms	6
Nutrition, diversity and health	9
Sustainable and adaptive management systems	14
Equitable and sustainable value chains	17
Looking forward	21
Key policy recommendations and potential programming actions	22
References	24

© Shutterstock

ACKNOWLEDGEMENTS

This brief is a product of an ongoing collaboration between FAO, People and Plants International, and the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT). It serves as a background document for partner countries and stakeholders involved in the FAO Technical Cooperation Programme Project on "Strengthening country capacities to enable forest-based contributions to healthy and sustainable agrifood systems", and stakeholders interested in enhancing and optimizing the benefits of forests, trees and wild species for biodiversity, climate and health. The brief also takes into account the outcomes of virtual workshops co-organized by FAO for countries across Asia-Pacific, Africa and Latin America and the Caribbean to exchange knowledge, experiences and jointly identify priority actions to enhance the sustainable use of non-wood forest products, including wild species, in support of agrifood systems transformation.

The authors are grateful to Hugo Bourhis, Diego Fallas-Conejo, Patrizia Fracassi, Giles Hanley-Cook, Bridget Holmes, Simona Sorrenti, Will Troy and Veronica Vargas Roman for their inputs. We would also like to thank the Charles Engelhard Foundation and Woods and Wayside International for their support of this process.

LAYOUT AND DESIGN – Gabriela Álvarez Anaya

Supporting this document is an illustrative collection of wild and forest food, and NWFP case studies. Each case study includes text by experts, video, resources, and other current and in-depth information. The collection of cases is expanding, and regularly updated, and can be found at: www.peopleandplants.org/case-studies.

Key messages

- **Local and indigenous forest food systems are hotspots for genetic, species, ecosystem, as well as dietary diversity.** Researching and conserving wild relatives of crops and traditional foods, and the agrifood systems of which they are a part, is critical for the conservation of biodiversity, sustainable food production, and improving food security and nutrition.

- **More than five billion people around the world depend upon forests and non-timber forest products** (NTFPs) for food, medicine and livelihoods. This includes within both the Global South and Global North.

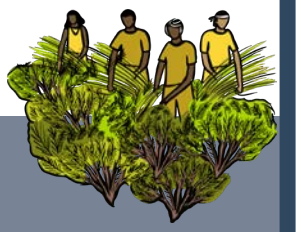
- **Forests and wild-harvested food species are an important complement to commodity agriculture,** and a critical part of smallholder food systems. However, in many regions they are under threat due to habitat destruction, land use change, pollution, overexploitation, climate change, population growth and urbanization.

- Conservation and sustainable use of forests, trees and natural ecosystems – which harbour countless medicinal, food, cultural and other useful species – are crucial to achieving global biodiversity and nutrition goals, including those of the Global Biodiversity Framework and the Sustainable Development Goals. They are also among the **most significant climate change mitigation strategies proposed in global policy today,** including within the UN Framework Convention on Climate Change.

- **Policymakers often lack information on the importance and role of forest foods and traditional food systems** because data collection is non-existent or poor. This in turn hampers the effectiveness of agrifood system policy, and to date has made the many environmental, health and livelihood benefits of forest foods and traditional food systems largely invisible.

© Shutterstock

WILD AND FOREST FOODS... AT A GLANCE



NTFP users

- **5.8 billion NTFP users globally** (Shackleton et al., 2022)
- **2.77 billion NTFP users in the Global South:**
  - 92.8% Africa
  - 91.2% Asia
  - 89.5% Latin America

  (Shvackleton et al., 2022)

Household use

- **77.3% of rural households harvest** wild foods in Asia, Africa and Latin America (Hickey et al., 2016)
- **26% of European households collect NWFPs...**
  - 90% regularly consume wild foods (Lovric et al., 2020)

Trees

60 000 TREE SPECIES worldwide
Schindler et al., 2022

- 10% have a medicinal or aromatic use
- 1/5 are directly used by humans for food, fuel, timber, medicines, horticulture and more
- 30% are threatened with extinction
- 142 are recorded as extinct in the wild

Plant species used

- 50 000 wild species used by 70% of the world's poor for food, medicine, energy, income and other practices... and by 50% of the global population
- 10 000 wild species used as food for humans (IPBES, 2022)
- 9 of 400 000 known plant species account for 66% of total crop production
- 95 species on average used in rural communities in Asia and Africa... 300–800 species per country (Bharucha and Pretty, 2010)

- **93% of crop pollinators were maintained in mixed-tree agroforestry systems in Indonesia (Barrios et al., 2017)**

© Betsie Nel

Introduction

Forests and biodiversity are the foundation of some of the world's most sustainable and resilient agrifood systems. These systems make a significant contribution to nutrition and health for local and global populations, and can be more accessible, productive, secure and sustainable than industrial agrifood systems.

Globally, policymakers within the UN Sustainable Development Goals, Global Biodiversity Framework, Convention on Climate Change and other processes, recognize that agrifood system transformation, and forest conservation, are critical. National governments have similarly identified these as country development priorities. This brief supports these policy goals, and greater examination of the potential for existing smallholder, traditional and forest food systems to contribute to agrifood transformation.

Deforestation and forest degradation, often driven by agriculture (Global Forest Watch, 2024), account for roughly a fifth of global greenhouse gas (GHG) emissions, and food systems contribute a third of GHG (Crippa et al., 2021). The Intergovernmental Panel on Climate Change (IPCC) identifies forest conservation as one of the most effective nature-based solutions to reduce GHG emissions (IPCC, 2022). Despite receiving significant attention for their role in mitigating and adapting to climate change and conserving biodiversity, the contributions of forests, trees and wild species to food systems are often overlooked in policy and practice. This persists even as the evidence in favour of promoting their sustainable use to transform unsustainable agrifood systems, and support forest conservation, continues to grow (Ulian et al., 2020; Cantwell-Jones et al., 2022; Ickowitz et al., 2022; IPCC, 2022).

© Akshata Mehta

Forests, woodlands and natural ecosystems harbour thousands of wild, semi-wild and managed plant, fungi and animal food species. The complex systems of which they are a part, made up of diverse activities that together produce food – including harvesting, management, cultivation, processing and preparation – grow from and depend upon traditional knowledge and practices, the interweave of cultural and biological diversity, and conservation of biologically diverse landscapes including forest biomes and woodlands.

An estimated 5.76 billion people across socioeconomic groups and geographic regions use NTFPs (Shackleton et al., 2022). Some 50 000 wild species, moreover, are used worldwide for food, medicine, energy, income, cultural identity and other practices, supporting half of the world's population and about 70 percent of the world's poor (IPBES, 2019). Ten thousand wild species are vitally important as food, particularly for Indigenous Peoples and rural communities. Yet countless plant and animal populations are also rapidly declining due to habitat destruction, land use changes, pollution, overexploitation, climate change, population growth and urbanization (FAO, 2019), with two in five species at risk of extinction (Royal Botanic Gardens, 2020).

This brief

This brief was prepared as a background document for FAO's Technical Cooperation Programme Project TCP/INT/3905, *Strengthening country capacities to enable forest-based contributions to healthy and sustainable agrifood systems*. The project aims to: 1) strengthen and institutionalize capacities to generate data and knowledge on NWFPs, wild species and associated agrifood systems to facilitate the generation of scientifically sound evidence for policy and finance decision makers; 2) promote an enabling environment by enhancing multi-sectoral dialogue, interventions and policies, ensuring representation of women, Indigenous Peoples and local communities; and 3) upscale interventions in support of sustainable use of NWFPs, wild species and associated food systems, identified by national stakeholders during the implementation of the project.

This brief is aimed at forest, agriculture and health practitioners, landscape and land-use planners and associated decision and policymakers. It reviews literature on the opportunities and challenges surrounding forest food and traditional food systems, focusing on three interrelated themes: **1) Nutrition, diversity and health; 2) Sustainable and adaptive management systems; and 3) Equitable and sustainable value chains.** The review includes a collection of case studies on different forest and wild foods, and agrifood systems that integrate forest foods and wild species. The case studies include information on species use, markets and management practices, and threats to sustainability and equity. They help to make visible the knowledge, experience and livelihoods of Indigenous Peoples and local communities (IPLC) and bring into view the widespread and critical management systems that feed much of the world's population, but too often exist on the margins of policy, and lack support. This brief concludes with recommendations for policymakers, government institutions, private sector entities and practitioners to help them make informed decisions in support of healthy, biodiverse and climate-resilient agrifood systems.

This work is part of a larger effort to help catalyse agrifood systems transformation by taking stock of the contributions made by forests, trees and wild species. The intention is to stimulate further exploration of the importance of forests, trees, wild species and associated agrifood systems, identify steps to conserve and support these systems as part of addressing health, nutrition, food security, biodiversity, bioeconomy climate and other concerns, and support more informed and effective policies.

© Shutterstock

Values for forests, trees and NWFPs to agrifood systems: findings from recent FAO workshops

Non Wood Forest Products:

- are bio-culturally rich resources essential for human food security, nutrition, and health, and for maintaining ecologically balanced food systems.
- blend scientific and traditional knowledge, create economic opportunities, provide decent employment, and can improve living conditions, particularly for vulnerable populations.

Forest-based agrifood systems:

- strengthen the resilience of natural ecosystems and human communities, making them crucial for climate mitigation and adaptation efforts.
- help conserve and rehabilitate degraded lands through climate-adapted and nutrition-sensitive practices.
- require effective governance frameworks that integrate statutory, customary, and market-based arrangements, along with collaborative forest management practices, and recognition of indigenous and local territories.

Empowering local communities in the sustainable management of forests, trees, and NWFPs:

- enhances livelihoods and can address the root causes of food insecurity, malnutrition, poverty, and biodiversity loss.

Forest foods, wild species and agrifood systems

Key terms

A number of authors have explored terminology associated with the range of species, products and agrifood systems addressed in this brief. Below is a brief summary of some key terms.

- **Agrifood systems –** sometimes used interchangeably with "food system", agrifood systems encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries and parts of the broader economic, societal and natural environments in which they are embedded (FAO, IFAD, UNICEF, WFP and WHO, 2023).
- **Forest food –** foods obtained by gathering and hunting in forests and woodlands, or originating in those habitats. It is used here synonymously with edible "non-wood forest products" and "non-timber forest products". Forest foods may be produced in different ways, including wild-harvested, semi-domesticated and cultivated.
- **Forest food system –** forest food systems refer to the complex and diverse activities that together produce food – including harvesting, management, cultivation, processing and preparation; these systems often depend on traditional knowledge and practices, the interweave of cultural and biological diversity and biologically diverse environments including forest biomes and woodlands.
- **Gathering –** gathering or harvesting refers to the collection of untended foods and other products not grown intentionally (ISIC, Rev.4, Code 0230; Muir et al., 2020).

© Shutterstock

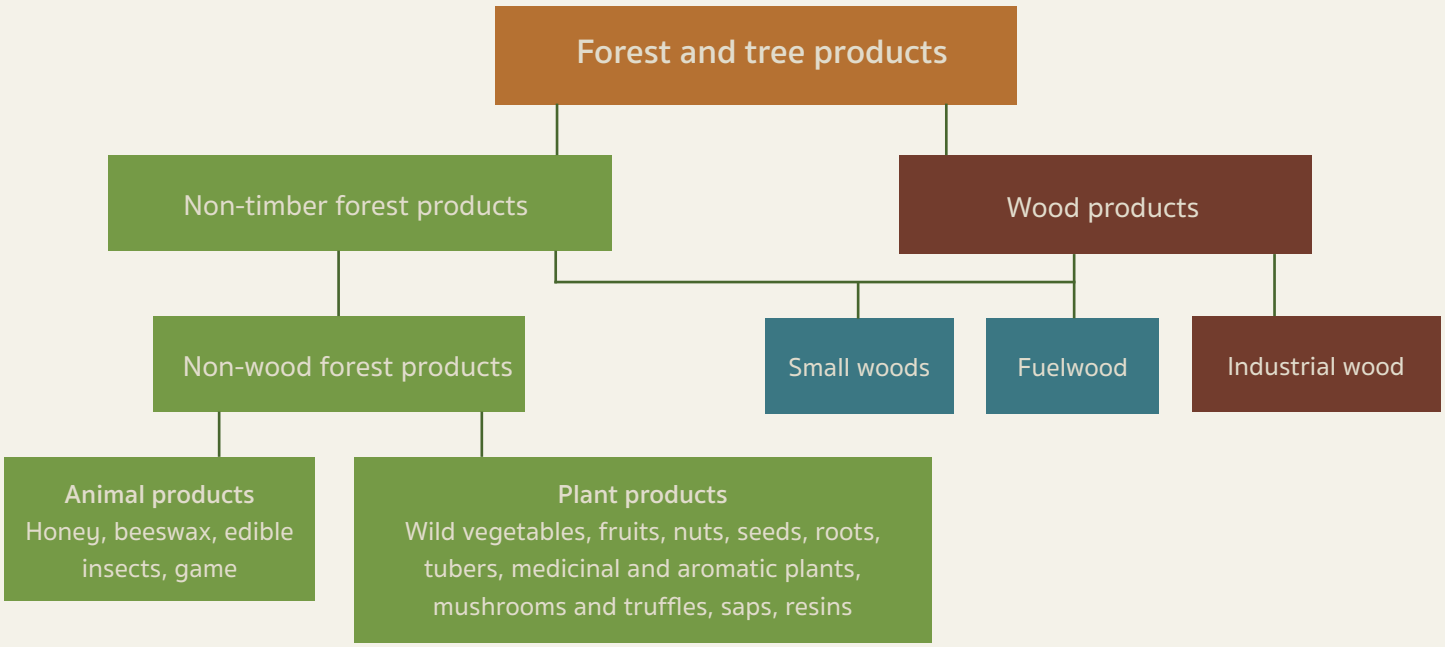
- **Non-wood forest products (NWFPs)/Non-timber forest products (NTFPs) –** Non-wood forest products have been defined by the FAO to as goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests (Walter, 2001). The term non-timber forest products, which much of the literature in this brief cites, is largely synonymous and the two terms are often used interchangeably. Both terms refer to plant, animal, insect, fungi and forest fish species and products used in raw or processed forms for food, medicine, energy, construction, decoration, utensils, spirituality, cultural and purposes other than timber. They are generally found in natural, modified or managed forested landscapes or other wooded land and trees outside forests, but are also understood to include species from a wide range of habitats beyond forests, such as grasslands, deserts, wetlands, mangroves and towns and cities (Shackleton and de Vos, 2022; Shackleton et al., 2011; Wiersum et al., 2014). The key difference between the terms NWFP and NTFP is that FAO's definition excludes all woody raw materials, including fuelwood and wood for utensils, tools and construction (Walter, 2001). See figure below.

- **Smallholder agriculture –** defined by FAO as those working up to 10 hectares, but often significantly less, these production systems usually include a mix of subsistence and cash crops and most of the labour is supplied by family members. In many parts of the world, these production systems incorporate wild and forest foods (Lopez Binnquist, 2024; Sardeshpande and Shackleton, 2019; Shanley et al., 2015; Wiersum, 2004; Gomez-Baggethum et al., 2013; Leakey et al., 2012; Ticktin and Shackleton, 2011).

- **Wild –** the term "wild" edible foods in this report refers to "populations existing and reproducing without human agency" (Shackleton and de Vos, 2022), "spontaneous forest products of biological origin" (Ingram et al., 2017b), or "untended biological resources obtained from the activity of gathering" and by extension not grown intentionally (Muir et al., 2020). However, many "wild" products are semi-domesticated, cultivated or managed to some degree by people and most habitats considered "wild" have been shown to be managed and modified by humans over time (Levis et al., 2017, 2018; Muir et al., 2020; Oslisly et al., 2013; Maezumi et al., 2018; Brondizio, 2004).

- **Wild species/Wild foods –** untended biological resources not grown intentionally, harvested through the activity of gathering (Muir et al. 2020; ISIC, Rev.4 Code 0230).

© Gabriela Álvarez



Adapted from: **FAO.** 1999. FAO Forestry: Towards a harmonized definition of non-wood forest products. Unasylva. No.198: Non-wood forest products and Income Generation. https://www.fao.org/4/x2450e/x2450e0d.htm#fao%20forestry. **Muir, G.F., Sorrenti, S., Vantomme, P., Vidale, E. & Masiero, M.** 2020. Into the wild: disentangling non-wood terms and definitions for improved forest statistics. International Forestry Review, 22(1): 101–119. www. ingentaconnect.com/contentone/cfa/ifr/2020/00000022/00000001/art00007

© Shutterstock

Nutrition, diversity and health

Key messages

- Modern food systems use a narrow range of plant species as part of food systems that are inherently fragile and vulnerable to unexpected or unforeseen shocks. There are an estimated 7039 identified known edible plant species that exist on the planet, with some estimates reaching as high as 30 000. However, fewer than 200 plant species currently make substantial contributions to food production globally, regionally or nationally, and only nine account for 66 percent of total crop production (FAO, 2019).

- In stark contrast, rural peoples often forage and manage hundreds of wild species, many gathered from the forest, averaging 100 useful species per location, and between 300 and 800 aggregately per country (Bharucha and Pretty, 2010; Laird et al., 2011). This figure reaches as high as 1403 species in some countries such as India (Ray et al., 2020). Wild foods were found to be harvested by some 77.3 percent of households in a multi-country survey across in Asia, Africa and Latin America (Hickey et al., 2016).

- Current research suggests a positive correlation between food species richness (the number of different species consumed per day) and diet quality (Lachat et al., 2018). Food composition data have shown the high and often superior nutritional content of neglected and underutilized species, local varieties and wild species compared to commercial cultivars (Burlingame et al., 2019; Li et al., 2016; Krug et al., 2023).

- Although management and use of wild foods exist along an economic and trade gradient – with some consumed in households only, others both sold and used for subsistence, and others entirely sold – a large proportion of wild food consumption in the Global South is for subsistence (Gogoi et al., 2023; Łuczaj et al., 2021; Shanley et al., 2015).

- In addition to contributing to human health, forests and associated food systems that retain ecological health and species diversity provide a diverse range of ecosystem services like water quality, flood control, wildlife habitat, healthy soils and carbon storage, and are homes to pollinators – all of which are essential for food production and healthy lives.

© Shutterstock

Contribution of forests, trees and wild species to food security and nutrition

Key findings	Methods and data sources	Sample size (*n*)
GLOBAL		
Fifty thousand wild species are used by half of the global population and 70% of the world's poor for food, medicine, energy, income and other practices; 20% (10 000 species) are used as food for humans.	A systematic review of the scientific literature and additional sources (IPBES, 2022).	N/A
High exposure to forests results in at least 25% greater dietary diversity compared to lack of exposure.	Demographic and Health Surveys (DHS) and Global MODIS Vegetation Continuous Field products (Rasolofoson et al., 2018).	N/A
Declines in animal pollinators could cause significant global health burdens from both non-communicable diseases and micronutrient deficiencies.	FAO food balance sheets and meta-analysis that sorted the pollinator-yield dependence of crops (Smith et al., 2015).	N/A
AFRICA		
Africa (21 countries) Statistically positive relationship between tree cover and fruit and vegetable consumption.	Demographic Health Survey Data and MODIS data on tree cover (Ickowitz et al., 2014).	93 000 children
Africa (15 sub-Saharan countries) Forest loss was negatively associated with child dietary diversity and consumption of nutritious food.	Demographic and Health Survey Data coupled with Global Forest Change dataset (Galway et al., 2018).	33 777 children
Africa (5 countries) Household dietary diversity and likelihood of consuming fruits increased with greater forest cover and a higher number of forest patches. One additional forest patch per square kilometre increased the odds of consuming fruits by up to 33%.	Geo-located World Bank Living Standard Measurement Surveys (LSMS) and global tree cover dataset from 2000 to 2016 (Rasmussen et al., 2020).	Between 1886 and over 10 000 rural households per country
Malawi Children living in areas with net forest cover loss were 19% less likely to have a diverse diet and 29% less likely to consume vitamin A-rich foods than children living in areas with no net change in forest cover.	Demographic and Health Survey Data and Satellite Remote Sensing Data (Johnson et al., 2013).	23 000 households
United Republic of Tanzania Ninety-two wild foods were reported to be used by the informants, including 45 forest species. Wild foods contributed only 2% of total energy in the diet but large percentages of vitamin A (RAE) (31%), vitamin C (20%) and iron (19.19%).	A qualitative 7-day food frequency questionnaire. Two quantitative 24-hour recalls on non-consecutive days (Powell et al., 2015).	274 dyads (children and mothers)

© Shutterstock

ASIA AND THE PACIFIC

India Access to a free collection of foods augments household dietary diversity by 77%.	National Sample Survey on Consumer Expenditure (Narayanan, 2021).	National; Not specified
Indonesia Tree-dominated land classes are associated with more frequent consumption of food groups rich in micronutrients.	Indonesia Demographic Health Survey; Vegetation cover from Indonesian Ministry of Forestry (Ickowitz et al., 2016).	3063 households
Viet Nam Wild vegetables contributed significantly to the overall micronutrient intakes, mostly carotene, vitamin C and calcium intakes.	Seven-day quantitative food frequency questionnaire (Ogle et al., 2001).	196 women aged 19 to 60 years
Thailand Eighty-five percent of adult daily energy from a mix of shifting cultivation and wild food harvest composed of 187 wild and 183 cultivated foods.	Interdisciplinary (standard anthropometric methods, 24-hour dietary recalls, ethnographic study, focus group discussion, in-depth interviews) (Kuhnlein et al., 2009).	86

LATIN AMERICA

Ecuador Wild leafy greens were estimated to contribute an additional 8% vitamin A, 7% iron, 12% vitamin C and 27% folate to children's recommended dietary intakes.	Semiquantitative food frequency questionnaire answered by mothers (Roche et al., 2017).	Not specified
Ecuador Wild and locally cultivated foods contributed 38.6% of total energy intake in Guasaganda. Consuming one additional local species was associated with a higher median mean adequacy ratio (MAR) for three macronutrients of 0·033 ($P < 0.001$) and a higher median MAR for nine micronutrients of 0·052 ($P < 0.001$).	Two non-consecutive quantitative 24-hour dietary recalls (Penafiel et al., 2019).	178 non-pregnant, non-lactating women
Brazil Wild species consumption was higher during the dry season. The number of wild species consumed was significantly higher in Carão (5.75 ± 3.86) than in Cachoeira (3 ± 2.82 ($P = 0.05$).	A modified version of 24-hour recall (consumption information record). Participants cite plants used in the past week (applied in two seasons) (do Nascimento et al., 2013).	66 women 68 men

OTHER

Canada Vitamin D blood concentrations were significantly positively correlated with diets based around traditional foods (fish, moose meat, duck or goose, rabbit, Indian medicine or tea, homemade soup and wild berries).	Three-month 36-food item food frequency questionnaire: Past month vitamin D questionnaire (interview-administered) (Mansuri et al., 2016).	Not specified

© Shutterstock

Néré (*Parkia biglobosa*): Sustainable management of a nutritionally important tree species

Barbara Vinceti, Bioversity International

Néré plays a significant role in the diet of rural communities across its range. The most valuable parts of the tree are the pods. The seeds are crushed, fermented and moulded into balls, used as a condiment (locally known as soumbala or dawadawa), usually combined with grain-based food items, in traditional soups and stews, consumed with sorghum or millet dumplings, or with porridge. Soumbala can be stored for long periods in earthenware pots and is an important source of proteins, essential amino acids (e.g. lysine), vitamins (e.g. riboflavin and vitamin C), essential fatty acids and minerals (Guissou et al., 2020; Termote et al., 2020), and a key ingredient of diets commonly based on carbohydrate staples (e.g. yams and cassava). The sweet pulp surrounding the seeds is eaten fresh or made into sweets and drinks. It is a source of energy and nutrients (e.g. glucids, proteins, carotenoids, vitamins A, B, C, and oligo-elements), and is important as a mineral supplement (Dao et al., 2021; Termote et al., 2020). The tree is undomesticated despite its great importance. The products of the plant are only collected from the wild or in "parklands" (agroforestry systems with high representation of valued tree species such as *Parkia biglobosa* and *Vitellaria paradoxa*), with very complex access rights to néré pods defined by gender, ethnicity, residence status, and seniority within a lineage (Pehou et al., 2020). In recent years, a significant amount of information has been generated to support the development of a conservation strategy based on complementary *in situ* and *ex situ* conservation approaches, taking into account farmers' perceptions together with morphological and molecular variables (Lompo et al., 2017, 2018, 2020). Farmers appear to have an active role in shaping the intraspecific diversity of the species, also affecting its overall spatial distribution, density, and structure of tree populations (Lompo et al., 2020). The species is retained in farmers' fields when these are cleared for agriculture, but also actively planted. Farmers have well-defined criteria to identify "plus" trees from which to obtain reproductive material. Natural populations of the tree are in decline (Lompo et al., 2017). Nevertheless, conservation efforts need to be strengthened, given the biotic and abiotic pressures affecting future availability of this resource, such as climate change, overgrazing, fire, cotton production and mining (Gaisberger et al., 2017).

© Barbara Vinceti

Two decades of logging and fire: Impact on forest foods and livelihoods along the Capim River, Brazil

Patricia Shanley, People and Plants International

In the early 1900s, selective logging of forests along the Capim River included extraction of only a handful of high-value timber species. Over time, the frequency and intensity of logging increased to include nutritious fruit and nut trees, as well as widely used medicinal oil trees (Shanley et al., 2002). Across two decades, collaborative research with community members was conducted on the changing ecology and use of the most widely consumed fruit species, bacuri (*Platonia insignis)*, piquia (*Caryocar villosum)*, and uxi (*Endopleura uchi)*, as well as species of medicinal use such as andiroba (*Carapa guianensis)*, and copaiba, (*Copaifera* spp.) and on the consumption of game.

Results indicate that over a period of 11 years, consumption of fruit such as piquia dropped by 80 percent, as fruit-bearing trees were logged. These fruit trees also contributed a significant proportion of protein to family diets by attracting game. At the outset of the research, payment to families for individual trees was the equivalent of USD 2.00 per tree. Findings illustrated that each of the three fruit species under study produced between a couple hundred to thousands of fruit annually, and that their nutritional and/or market value as fruit far outweighed the value of timber. During the decades in which timber extraction became more intense, community access to these regional fruit species of highest nutritional and medicinal value declined markedly. And ironically, while these forest fruit trees were once considered "*frutas dos pobres*" (fruits of the poor) with low prices, they have now become highly sought after by all classes of society and have significantly increased in economic value. In the Capim River region, due to landscape degradation by logging, forests became prone to fire, which tore through communities for months at a time. During the 1990s, areas surrounding the community began to be transformed into cattle ranches, and more recently, into oil palm plantations. However, the Capim River communities played a central role in helping to generate research regarding the impacts of declining access to highly valued fruits, and game. They also took the next step and helped to communicate their experience to other Amazonian communities facing forest loss across the Amazon basin (Shanley et al., 2010).

© Joel Sartore

Sustainable and adaptive management systems

Key messages

- Wild or forest foods are harvested from a wide range of habitats, including forests, grasslands, deserts, wetlands, mangroves, and towns and cities (Shackleton and de Vos, 2022). They are commonly, but not always, part of smallholder management systems that maintain high species diversity, reduce risk, and integrate multiple habitats and uses (Sardeshpande and Shackleton, 2019; Shanley et al., 2015; Gomez-Baggethum et al., 2013).

- Management of wild foods and NWFPs occurs along a continuum, or gradient, from low intensity subsistence harvests to higher intensity harvest of species for global bulk trade. As management intensity increases, retention of biodiversity usually decreases, and volumes in trade increase. Management intensity depends upon a range of factors: availability and proximity of forests and resources; land tenure and resource/access rights; distance to markets; cultural backgrounds of harvesters and producers; availability of labour for species in trade; plant part used and if a species will be killed or will persist after harvest; habitat requirements; and whether species will be used for subsistence or traded (Shanley et al., 2015; Leakey, 2019; Shackleton et al., 2011; Wiersum, 2004; Homma, 2012; Dawson et al., 2014; van Eerbeek, 2019; Richards and Saastamoinen, 2010).

- Traditional management systems are usually dynamic and resilient, reducing risk rather than maximizing gain, and involve the management and use of a wide range of species and habitats, and practices developed over generations including agriculture, semi-domestication, fallow and secondary forest management, enrichment planting and home gardens.

- Traditional, cultural, social and ecological agrifood systems are often hotspots for plant and landscape diversity, and should be strengthened where degraded and eroding. National policy and conservation efforts can build on these systems by documenting, assessing, monitoring, supporting and scaling up traditional practices where appropriate.

- The greatest threats to forest foods, and sustainable and adaptive smallholder agrifood systems, include clearance of forests and smallholder farms for commodity and other simplified forms of agriculture, and logging.

© Shutterstock

Forest and wild food systems: A glimpse of rich biological and cultural diversity

Country / Region	Indigenous local group (IPLC)	Recorded no. of edible species
Colombia	Inganos tribe	160 wild species (roots, fruits, mushrooms, insects, palm tree products) (Kuhnlein et al., 2009)
Ecuador (El Oro, Loja, Zamora-Chinchipe)	Mestizo farmers, Shaur and Saraguros Indigenous Peoples	354 wild plants (85% have edible fruits) (Van den Eynden et al., 2003)
Colombia (nation-wide)	Not specified	703 wild edible fruit species, 76 families (López and Garcia, 2021)
India (nation-wide)	Not specified	1403 edible species (Ray et al., 2020)
India (Andhra Pradesh)	33 tribes	156 wild species (55 trees, 27 shrubs, 18 climbers) (Reddy et al., 2007)
India (Achanakmaar-Amarkantak Biosphere Reserve)	Baiga, Gond, Kol, Oraon communities	172 wild plants (60 vegetables, 70 fruits-seeds-nuts, 23 tubers, 19 mushrooms) (Mishra et al., 2021)
Southwest China (Jiangcheng County)	Dai, Hani and Yao peoples	211 wild edible plants, 71 families, 151 genera (Cao et al., 2020)
United Republic of Tanzania (East Usambara Mountains)	Wasambaa, Bondei, Zigua tribes	92 wild species (Powell et al., 2015)
Indonesia (West Aceh)	Local communities in the Ulu Masen Protected Forest	53 wild fruit plants (Suwardi et al., 2022)
Cameroon	Bakweri	More than 400 species. Forty-five percent of local livelihoods come from wild and native species (Laird et al., 2011; 2007)
Uganda	Forest dwellers in 8 forest reserves in Teso-Karamoja region	100 edible plant species in 47 families (Ojelel et al., 2019)
Türkiye (western and central Anatolia)	Anatolian Peoples	121 wild plants (Dogan et al., 2004)
Western Himalayas	Kashmir, Jammu, Azad Kashmir, Ladakh	209 wild species (109 vascular plants and 13 mushrooms, 14 mammals, 22 birds, 21 fish) (Haq et al., 2022)

© Shutterstock

Oak agroforestry:
Managing high biodiversity landscapes for multiple products

The oak agroforestry systems of the Iberian Peninsula, referred to as montado in Portugal and dehesa in Spain, produce a wide variety of wild and cultivated products and provide numerous ecosystem services. Montados are used as grazing grounds for cattle, sheep and goats but also produce wild game, mushrooms, wild herbs, honey, fuelwood and cork beneath a canopy of holm oak (*Quercus rotundifolia*) and/or cork oak (*Quercus suber*). To the untrained eye, these systems may appear to be ecologically depauperate, but the deliberate intermixing of montado, forestland, shrubland and open land creates a heterogeneous landscape that supports a high biodiversity of flora and fauna, including endangered and vulnerable species (Simonson et al., 2018; Muir et al., 2020).

These agroforestry systems are so critical to biodiversity that the European Union has recognized the three million acres of dehesa/montado on the Iberian Peninsula as "Habitats of Community Importance". While the Iberian agroforestry systems receive much scholarly attention, other analogous agroforestry systems – also informed by generations of experimentation and practice – exist around the world.

© Xerces Endowment

Equitable and sustainable value chains

Key messages

- Local and regional trade of wild plants and NWFPs is often difficult for policymakers to grasp, with figures for this trade even more "invisible" than elusive global trade figures. However, in many cases local markets can be larger, and more reliable and sustainable than global markets. It is critical for effective policymaking that we fill gaps in data on NWFPs in trade, as well as those consumed for subsistence.

- Numerous studies demonstrate forest and wild foods contribute to household incomes in a range of ways, and to varying degrees, and are part of a wider portfolio of livelihood strategies (Chaudhury et al., 2021; Awono, 2017; Shanley et al., 2015; Ingram, 2014).

- Contributions of forests to rural households, particularly in the Global South, range from 15 percent to 40 percent of total household income (Aung et al., 2014). In India alone, NWFPs support close to 275 million people, with IPLCs deriving up to 40 percent of their annual income from their collection (Government of India, 2023), and in Cameroon 16 high-value NWFPs were estimated to have an annual economic value of USD 64.7 million, a trade involving 283 000 people (Awono et al., 2016).

- Global markets for wild plants cover a range and diversity of sectors. They include "biotrade" companies that trade in raw materials, usually for the cosmetic and personal care, flavour and fragrance, food and beverage, and botanical medicine sectors. These products include shea, acai, gum arabic, rooibos and devil's claw. These can be niche markets with a focus on environmental and social responsibility, or they can be bulk commodity trade. Wild plants and biodiversity also play a role in "biodiscovery" companies that collect samples and undertake advanced research on biological and genetic resources, including the pharmaceutical, biotechnology, seed and crop protection, food and beverage industries.

- Globally, the value of the international trade in medicinal and aromatic plant species has almost tripled from USD 1.3 billion in 1998 to USD 3.3 billion in 2018 (UN Comtrade, 2018), although these figures are known to be underestimates. The economic value of trade in ginseng species (wild and cultivated) is thought to be in excess of USD 2.1 billion (Manzanilla et al., 2018), and cork (*Quercus suber*), which accounts for 2 percent of all exported Portuguese goods, had an estimated trade value of USD 1.96 billion (APCOR, 2019; Workman, n.d.). The market for maple syrup in Canada totalled CAD 558.5 million in 2020 (Government of Canada, 2021).

- In Europe, including formally and informally marketed and self-consumed products, the value of wild forest products (NWFPs) is projected to rise to some EUR 23 billion per year (Lovric et al., 2020). In addition to markets for new and "re-emerging" products, demand for "experiential" services such as recreational gathering (e.g. mushrooms, chestnuts), forest bathing and nature tourism are also growing (Martínez de Arano et al., 2021).

© Shutterstock

Livelihoods, markets and value chains – a few cases

Agarwood
Aquilaria species, occ. *Gyrinops* species

Origin – Southeast Asia
Cultivated/Wild – Harvested from wild and plantation forests
Use – The aromatic wood is used in incense and perfumes
Trade data – Global trade estimated at USD 6–8 billion (Akter et al., 2013)
Livelihoods – Unknown

American ginseng
Panax quinquefolius

Origin – Native to North America
Cultivated/Wild – Wild-harvested and cultivated
Use – The root of this herbaceous plant is used for medicinal purposes
Trade data – 2008–2012, average annual harvest (dry) 64 719 lbs (Frey et al., 2018). Annual revenue for harvesters between 2000 to 2007 was USD 22–43 million (Chamberlain et al., 2013)
Livelihoods – Unknown

Argan tree
Sideroxylon spinosum (syn. *Argania spinosa*)

Origin – Endemic to northwest Africa, notably Morocco
Cultivated/Wild – Wild stands. It is also cultivated in Israel
Use – The tree's fruit kernel produces an oil used in food preparation and cosmetics
Trade data – Morocco's yearly production is about 4400 tons; Argan oil exports were worth USD 30 million (El Ouadi, 2018)
Livelihoods – More than 4000 women employed (mostly Amazigh/Berber) in 300 cooperatives (El Ouadi, 2018)

Bush mango
Irvingia gabonensis
Irvingia wombulu

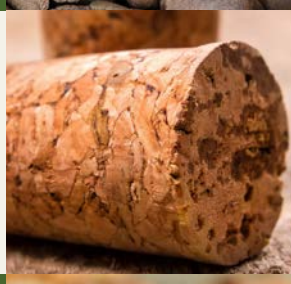
Origin – West and Central Africa, from Senegal to Angola
Cultivated/Wild – Wild and semi-domesticated
Use – Commercial use: weight loss, appetite suppressant, lower cholesterol, and others
Traditional use: widely used and sold as condiment and medicine for centuries
Trade data – Market in 2016 in Cameroon estimated at USD 9 428 710 (Awono et al., 2016; Ingram et al., 2017a). In 2007 an estimated 2 390 920 kg was exported from Cameroon to Nigeria (value of USD 7.2 million) and 302 050 kg to Equatorial Guinea and Gabon (value of USD 900 000) (Laird et al., 2020)
Livelihoods – Approximately 5190 people work in one of the bush mango value chains – ending in 24 markets in southern Cameroon. Bush mango income contributes between 18% and 33% of harvester household annual incomes (Ingram et al., 2017a; Ndumbe et al., 2022)

Brazil nut
Bertholletia excelsa

Origin – Amazon basin (Plurinational State of Bolivia, Brazil, Peru)
Cultivated/Wild – Wild-harvested
Use – The nut, high in selenium, is internationally traded
Trade data – 26 100 metric tons produced in 2019–2020 (INC, 2020) Bolivia earned USD 205 million from exports in 2018 (van der Wal, 2021)
Livelihoods – 14 000 harvesters, 8000 processors employed in Bolivia (van der Wal, 2021)

Cork
Quercus suber

Origin – Mediterranean basin
Cultivated/Wild – Natural stands (over 1.5 million ha managed for cork oak in Europe)
Use – Inner bark is used for bottle stoppers, flooring, insulation and handbags
Trade data – Portugal: EUR 1.2 billion annually – representing 61% of cork exports (Martinez de Arano et al., 2021)
Livelihoods – 100 000 employed in Portugal, Spain, Italy, France, Morocco, Tunisia and Algeria (Gifford, 2016)

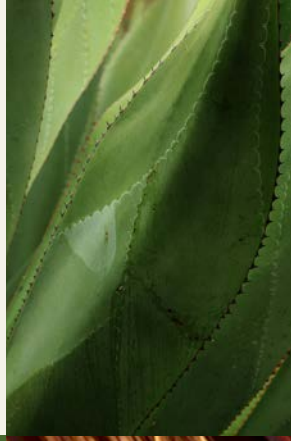


Gum arabic
Senegalia senegal
Various other species

Origin – Sahel region (Senegal to Somalia); Sudan is the largest producer
Cultivated/Wild – Wild stands
Use – The tree's sap is a food additive and medicine; it is also used in cosmetics and industrial applications
Trade data – Yearly global exports of 155 000 tons (2014–2016); export revenue for same period was USD 337 million (UNCTAD, 2018). It accounts for 15% of Sudan's exports (Hassan, 2017)
Livelihoods – Five million Sudanese (more than 10% of the population) have direct or indirect dependance on the gum arabic industry (Hassan, 2017)

Mezcal
59 *Agave* spp.

Origin – Mexico
Cultivated/Wild – Intensively cultivated by the industry. Traditionally harvested from the wild
Use – Traditionally used for fibers, in cooking, to make fermented and distilled drinks. Commercial use: distilled drinks – mezcal and tequila
Trade data – In 2020, 7.9 million litres of mezcal were produced, of which 60% is destined for export, by 313 different brands (Consejo Regulador del Mezcal, CRM, 2023).The mezcal market was valued at USD 727.11 million in 2019 and is projected to reach USD 1136.55 million by 2027 (The Insight Partners, 2021)
Livelihoods – The tequila and mezcal industry generated almost six thousand jobs in 2018 (INEGI, 2019). The importance of mezcal for household use and in the local economy is not reflected in this figure



Rattan
Various species

Origin – Asia and Africa
Cultivated/Wild – Wild-harvested, also cultivated
Use – The vines are used to produce furniture, baskets, mats, handicrafts and cordage
Trade data – International trade in 2018 worth USD 350 million (International Bamboo and Rattan Organisation, INBAR, 2020)
Livelihoods – 700 million people use or trade in rattan (Dransfield and Manokaran, 1993)

Rhodiola
Rhodiola spp.

Origin – Circumpolar distribution from the low-Arctic to high-temperate regions of Asia, Europe and North America
Cultivated/Wild – Primarily wild-harvested
Use – Used in ethnomedicines of Arctic peoples, as well as in national systems of traditional medicine. Commercial products: herbal medicine, cosmetics, sports medicine and energy drinks
Trade data – The value of the global market for dry extract of *Rhodiola rosea* root in 2015 estimated at about USD 27.06 million, with nearly 75% of the extract volume manufactured in China
Livelihoods – *Rhodiola rosea* is among the most commonly wild collected plants by hunters in the Russian Federation Far East for additional income (Brinckmann et al., 2021)

Rooibos
Aspalathus linearis

Origin – Endemic to South Africa's Western and Northern Cape provinces
Cultivated/Wild – Intensively cultivated for commercial use. Traditionally gathered from the wild
Use – South Africa's oldest and most successful indigenous natural product industries. Available globally in the form of a caffeine-free tea (Wynberg, 2020)
Trade data – ZAR 300-million local enterprise (USD 22.2 million) in the hands of about 300 commercial farmers who cultivate 93% of the planted area. Represents 10% of the growing global herbal tea market (Wynberg, 2020)
Livelihoods – Employing some 5000 people. About 200 small-scale farmers produce only 2% of all rooibos tea (Wynberg, 2019)

Shea tree
Vitellaria paradoxa

Origin – Sudano-Sahelian region
Cultivated/Wild – Cultivated and wild-harvested
Use – Kernel provides an edible fat used in foods and cosmetics
Trade data – African exports of 350 000 million tonnes per year (Iddrisu et al., 2017). Industry valued at USD 90–200 million per year (Chen, 2017)
Livelihoods – 3 million West African women employed (Chen, 2017). Land use and land cover changes have impacted ecological sustainability and livelihoods (Wardell, 2021)

Sugar maple
Acer saccharum, occ. other *Acer* species

Origin – Canada and the United States of America
Cultivated/Wild – Natural stands
Use – Tree sap is made into a sweetener
Trade data – Canada produced 14.3 million gallons of syrup in 2020, worth CAD 558.5 million (Government of Canada, 2021). US 2021 production was 3.42 million gallons; 2020 value of syrup was USD 132 million (USDA, 2021)
Livelihoods – In 2016, there were 5340 maple farms in Canada (Government of Canada, 2021); in 2017 there were 9492 maple farms in the United States (Atlantic Corporation, 2019)

Commercializing an indigenous agroforestry tree: *Canarium indicum* in Papua New Guinea

Shahla Hosseini-Bai, Helen M. Wallace, Dalsie Hannet,
Birte Komolong, Elektra Grant, Godfrey Hanne

Canarium indicum (galip nut) has been domesticated for over 60 00 years in the Pacific (Thomson and Evans, 2006). Over time, farmers have been selecting the best varieties to plant on their farms or in their home gardens and valuable trees have been conserved and propagated for generations. Commercialization of this species allowed communities living in urban areas to access this nutritious nut. Currently, the commercialization of canarium nuts is progressing with support from the Australian Centre for International Agricultural Research (ACIAR) and other projects targeted to Pacific Island communities. Semi-commercial processing methods have been developed and a growing industry of small and micro-enterprises has been established (Bai et al., 2017, 2021; Wallace et al., 2021). This has improved the accessibility of canarium nuts and allowed for purchasing to be more convenient, particularly for urban dwellers, thus improving the nutritional intake available to a wider community. Currently, a range of various value-added products exist in the market that have helped to improve the livelihood of the Pacific Peoples. The range of products include canarium meal, flour, oil, cakes and cookies. Canarium oil is a valuable oil already used in various cosmetic products such as soaps, creams, lotions or as a specialty cooking oil. Currently, these products mainly target tourists and suitcase markets, particularly in Vanuatu. The annual value of the domestic market was estimated at AUD 100 million (based on consumption of 4000 million tonnes/year, i.e. 2 million people each eating 2 kg/year). Galip is not a new crop to farmers, and its wider cultivation would have benefits independent of the success of potential export markets. Traditional knowledge on forest food sources is diminishing and canarium trees are often felled for timber for building houses due to high population growth rates. Uncontrolled logging is further threatening wild canarium resources in the forests.

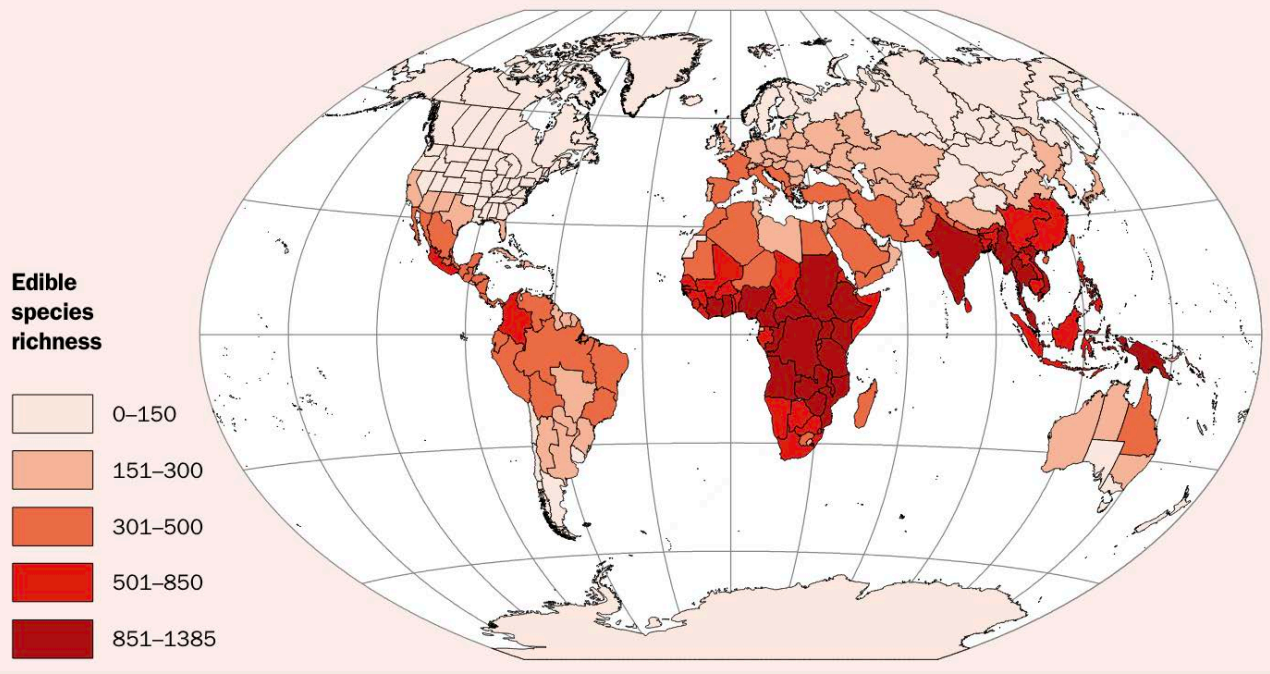
© Shahla Hosseini-Bai

Looking forward: Enabling conditions for forest, wild and traditional agrifood systems

Agrifood systems have moved to centre stage within global and national policy, identified as a major environmental, food security and nutrition challenge. At the same time, the importance of forests and high diversity smallholder and traditional food systems – "agroecology" or "agroforestry" as they are often referred to in policy processes – are emerging as part of a patchwork of solutions. As global policymakers and countries look for ways to develop or enhance biodiversity-friendly and climate-smart agriculture, one place to look is traditional, forest and wild species-based systems. These systems have developed over generations in connection with specific places, and often embody priorities for global policy today, including: biological and cultural diversity; natural forests and the suite of plant, fungi and animal species they harbour; flood resilience; production of high quality water; food security; carbon sequestration; and improved nutrition and human health. Enabling policies and legislative frameworks can strengthen existing systems of traditional use, and support the contributions of forests, trees and wild species to more biodiverse, nutritious and environmentally sound agrifood systems (Webb et al., 2020).

The global species richness, by country or state, of 6959 of the 7039 edible plant species identified by the review team

The darker shading highlights locations where there is high abundance of edible plant species



Source: **Royal Botanic Gardens, Kew.** 2020. State of the world's plants and fungi. A. Antonelli, C. Fry, R.J. Smith, M.S.J. Simmonds, P.J. Kersey, et al., eds. Royal Botanic Gardens, Kew. DOI: 10.34885/172

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

© Shutterstock

DIVERSITY, NUTRITION & HEALTH

Support traditional forest food systems and promote diversity in future food systems

SUSTAINABLE & ADAPTIVE MANAGEMENT SYSTEMS

Support traditional management systems and strengthen sustainable management practices to bolster genetic, species and ecosystem diversity

Key policy recommendations and potential programming actions

- **Conduct** extensive outreach and education initiatives to strengthen awareness of the relationship between healthy, biodiverse foods and forests, and traditional management systems.
- **Improve** the evidence base on the importance of forest foods in local and indigenous food systems, and biodiversity to diets more generally (e.g. food composition of NWFPs/forest foods, dietary intake methods).
- **Assess** the impacts of commercialization on household food security and nutrition, and livelihoods.
- **Promote** diversity in future food systems by exploring the potential of local biodiversity to fill nutrition gaps or address health problems, or contribute to new crop development.

- **Merge** local and scientific knowledge to guide more appropriate land-use planning, including to restore soils and degraded lands and promote conservation initiatives that support traditional forest management practices.
- **Intensify** responsible assessment and monitoring of NWFPs, wild foods and associated agrifood systems, including different uses.
- **Assess** the impact of human use as well as environmental factors such as climate change on potential supply of NWFPs and traditional agriculture.
- **Explore** the ecological and sustainability implications of NWFPs/forest food harvests, including for commercial purposes.
- **Investigate** the integration of forest/NWFPs into different management regimes.
- **Reorient** domestication to help shape diversity by helping direct research and practice towards incorporating higher levels of biodiversity in production systems (e.g. Krug et al., 2023; Li and Siddique, 2018).

EQUITABLE & SUSTAINABLE VALUE CHAINS

Build capacity in government, producer, and other communities to enable sustainable harvesting, trade, management and processing of wild and forest foods, to increase benefits for local groups, including improved health and forest conservation

- **Research** and undertake training in adding value to forest or wild foods, such as processing to extend shelf life.
- **Access** to information and capacity development on quality standards, including on food safety, hygiene, handling and processing to maximize health benefits.
- **Sharpen** marketing/organizational and business skills to access markets and generate income sustainably.
- **Produce** guidance on sustainable harvest and equitable and legal trade, including access to and benefits from certification schemes.
- **Capture** traditional knowledge in the development of new ingredients and products, cultivation and processing techniques, with consent and involvement of local groups and traditional knowledge holders.

ENABLING INSTITUTIONAL ENVIRONMENT

Enhance mutually beneficial linkages between agriculture, forestry and health sectors

- **Develop** mechanisms for multisectoral dialogues to share lessons and knowledge, and build opportunities for joint-planning and streamline laws, considering the ways in which laws, policies and programming relate to each other.
- **Maximize** nutrition and health by improving the conservation and management of nutritious NWFPs in forest and land-use planning, and enhancing sustainable use.
- **Take measures** to mainstream biodiversity into nutrition policies, programmes and action plans on nutrition, for example through mechanisms promoting traditional and wild fruits, vegetables (see, for example, Voluntary Guidelines for Mainstreaming Biodiversity).
- **Explore** the potential to integrate customary and statutory law and governance systems, honouring longstanding legal traditions in forested regions, including land tenure and resource rights.

DATA & KNOWLEDGE

Making wild food harvests and local use visible

- **Explore and document** traditional uses of NWFPs and forest foods, and smallholder agriculture.
- **Institutionalize** interministerial collaboration on data collection to capture the economic, health and ecological values of forest foods and systems.
- **Integrate** NWFPs, forest and wild foods in existing dietary intake surveys, national or subnational surveys on livelihoods and in analyses on food composition.
- **Integrate** NWFPs in national forest inventories, including information on socioeconomic uses.
- **Capture information** on local and regional markets, which are significant but largely invisible (Chamberlain and Smith-Hall, 2024).

© Shutterstock

References

Akter, S., Islam, M.T., Zulkefeli, M. & Khan, S.I. 2013. Agarwood production – a multidisciplinary field to be explored in Bangladesh. *International Journal of Pharmaceutical and Life Sciences*, 2(1):22–32.

Associação Portuguesa da Cortiça, APCOR. 2019. Cork. Information bureau. 2019 Cork sector in numbers. In: Portuguese Cork Association. www.apcor.pt/wp-content/uploads/2019/02/CORK-SECTOR-IN-NUMBERS_EN.pdf

Atlantic Corporation. 2019. Maple syrup markets and growth opportunities. Prepared for: Vermont Agency of Agriculture, Food & Markets. https://agriculture.vermont.gov/sites/agriculture/files/documents/AgDevReports/Maple%20Syrup%20Market%20Research%20Report.pdf

Aung, P.S., Adamb, Y.O., Pretzschc, J. & Peters R. 2014. Distribution of forest income among rural households: a case study from Natma Taung national park, Myanmar. *Forests, Trees and Livelihoods*, 24(3):190–201, DOI: 10.1080/14728028.2014.976597

Awono, A. 2017. Etude "chaîne de valeur" des produits forestiers non-ligneux permettant un développement culturellement adapté des Peuples Autochtones d'Afrique Centrale: Cas du Cameroun. Rainforest Alliance, The World Bank.

Awono, A., Foundjem Tita, D., Atyi, R. & Levang, P. 2016. Vegetal non-timber forest products in Cameroon, contribution to the national economy. *International Forestry Review*. Vol.18(S1) DOI: 10.1505/146554816819683708

Bai, S.H., Hannet, D., Hannet, G., Grant, E., Komolong, B., Jones, K. & Wallace, H.M. 2021. Effects of fruit depulping on kernel quality of Canarium indicum. *Acta Horticulturae*, 1340: 145–148.

Bai, S.H., Nevenimo, T., Hannet, G., Hannet, D., Jones, K., Trueman, S.J., Grant, E.L., Walton, D.A., Randall, B. & Wallace, H.M. 2017. October. Freezing, roasting and salt dipping impacts on peroxide value, free fatty acid and fatty acid concentrations of nut kernels. *Acta Horticulturae*, 1256: 71–76.

Barrios, E., Valencia, V., Jonsson, M., Brauman, A., Hairiah, K., Mortimer, P.E. & Okubo, S. 2018. Contribution of trees to the conservation of biodiversity and ecosystem services in agricultural landscapes. *Int. J. Biodiv. Sci. Ecosyst. Serv. Manag.*, 14(1): 1–16.

Bharucha, Z. & Pretty, J. 2010. The roles and values of wild foods in agricultural systems. *Phil. Trans. R. Soc. B.,* 365: 2913–2926.

Brinckmann, J.A., Cunningham, A.B. & Harter, D. 2021. Running out of time to smell the roseroots: Reviewing threats and trade in wild Rhodiola rosea L. *Journal of Ethnopharmacology,* 269: 113710.

Brondízio, E.S. 2004. From staple to fashion food: shifting cycles and shifting opportunities in the development of the açaí palm fruit economy in the Amazon estuary. In: Working Forests in the Neotropics: conservation through sustainable management? pp. 339-365. Columbia University Press.

Burlingame, B., Vogliano, C. & Eme, P.E. 2019. Chapter Five – Leveraging agricultural biodiversity for sustainable diets, highlighting Pacific Small Island Developing States. In: D. Barling & J. Fanzo, eds. Advances in food security and sustainability, 4: 133–173. DOI: 10.1016/bs.af2s.2019.06.006

Cantwell-Jones, A., Ball, J., Collar, D., *et al.* 2022. Global plant diversity as a reservoir of micronutrients for humanity. *Nat. Plants*, 8: 225–232. DOI: 10.1038/s41477-022-01100-6

Cao, Y., Li, R., Zhou, S., *et al.* 2020. Ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, Pu'er, Southwest China. *J. Ethnobiology Ethnomedicine*, 16: 66. DOI: 10.1186/s13002-020-00420-1

Chamberlain, J.L. & Smith-Hall, C. 2024. Harnessing the full potential of a global forest-based bioeconomy through non-timber products: Beyond logs, biotechnology, and high-income countries. Forest Policy and Economics, 158: 103105.

Chamberlain, J.L., Prisley, S. & McGuffin, M. 2013. Understanding the relationships between American ginseng harvest and hardwood forests inventory and timber forest to improve co-management of the forests of eastern United States. Journal of Sustainable Forestry, 32: 605–624.

Chaudhury, G., Basumatari, M., Darji, C., Ahmed, A.F., Borah, D., Sah, R.K., Devi, A., Hazarika, N. & Dutta, G. 2021. Economic significance of wild bioresources to rural communities in the Eastern Himalayan state of Assam, Northeast India. Trees, Forests and People, 5:100102. DOI: 10.1016/j.tfp.2021.100102

Chen, T. 2017. The impact of the shea nut industry on women's empowerment in Burkina Faso: a multi-dimensional study focusing on the Central, Central-West and Hauts-Bassins regions. Social Protection and Forestry Working Paper 3. Rome, FAO.

Consejo Regulador del Mezcal, CRM. 2023. Informe estadístico. https://comercam-dom.org.mx/wp-content/uploads/2023/05/INFORME-2023_PUBLICO.pdf

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F.N. & Leip, A. 2021. Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food,* 2: 198–209. DOI: 10.1038/s43016-021-00225-9

Dao, A.S., Parkouda, C., Traoré, M.E., Aimée, W.G., Barbara, V., Céline, T., Mattia, M. & Bassolé, I.H.N. 2021. Comparison of chemical composition of fruit pulp of Parkia biglobosa (Jacq.) Benth from different ecoregions. *African Journal of Food Science,* 15(1): 26–32. DOI: 10.5897/AJFS2020.2010

Dawson, I.K., Leakey, R., Clement, C.R., Weber, J.C., Cornelius, J.P., Roshetko, J.M., Vinceti, B., Kalinganire, A., Tchoundjeu, Z., Masters, E. & Jamnadass, R. 2014. The management of tree genetic resources and the livelihoods of rural communities in the tropics: Non-timber forest products, smallholder agroforestry practices and tree commodity crops. *Forest Ecology and Management,* 333: 9–21.

do Nascimento, V.T., de Lucena, R.F.P., Maciel, M.I.S. & de Albuquerque, U.P. 2013. Knowledge and use of wild food plants in areas of dry seasonal forests in Brazil. *Ecology of Food and Nutrition,* 52(4): 317–343. DOI: 10.1080/03670244.2012.707434

Dogan, Y., Baslar, S., Ay, G., *et al.* 2004. The use of wild edible plants in western and central Anatolia (Turkey). Econ Bot, 58: 684–690. DOI: 10.1663/0013-0001(2004)058[0684:TUOWEP]2.0.CO;2

Dransfield, J. & Manokaran, N., eds. 1993. Plant resources of Southeast Asia – rattans. Wageningen, the Netherlands, Pudoc Scientific Publishers.

El Ouadi, I. 2018. Argan oil: Is outside exploitation of Morocco's liquid gold imperiling local coops? In: Inside Arabia: Voice of the Arab People. https://insidearabia.com/argan-oil-outside-exploitation-imperiling-local-coops

FAO. 1999. FAO Forestry: Towards a harmonized definition of non-wood forest products. Unasylva. No.198: Non-wood forest products and Income Generation. https://www.fao.org/4/x2450e/x2450e0d.htm#fao%20forestry.

FAO. 2019. The state of the world's biodiversity for food and agriculture. In: J. Bélanger & D. Pilling, eds. Rome, FAO Commission on Genetic Resources for Food and Agriculture Assessments. www.fao.org/3/CA3129EN/CA3129EN.pdf

FAO. 2023. Proceedings from the workshop: Proceedings from the workshop: Forest food systems and their contribution to food security and nutrition - Defining priorities for the sustainable use of forest plants, fungi and insects in Latin America and the Caribbean. Rome. https://openknowledge.fao.org/server/api/core/bitstreams/d2d1b39a-e13f-4ebc-916d-f186e0f391e1/content

FAO, IFAD, UNICEF, WFP & WHO. 2023. The state of food security and nutrition in the world 2023. Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum. Rome, FAO. DOI: 10.4060/cc3017en

FAO & Korea Forest Service. 2023. Proceedings from the workshop: Forest food systems and their contribution to food security and nutrition, defining priorities for sustainable use in Asia Pacific. Rome. https://openknowledge.fao.org/server/api/core/bitstreams/4fa2d33c-08ff-480e-a13a-751e98880a71/content

FAO & Ministry of Forestry and Wildlife of Cameroon. 2024. Proceedings from the workshop: Forest-based agrifood systems - Defining priorities on the sustainable use of forest foods in Africa. Rome. https://openknowledge.fao.org/server/api/core/bitstreams/665fba88-1b48-4bb0-ab99-0d0906fd1ff7/content

Frey, G.E., Chamberlain, J.L. & Prestemon, J.P. 2018. The potential for a backward-bending supply curve of non-timber forest products: an empirical case study of wild American ginseng production. *Forest Policy and Economics*, 97: 97–109.

Gaisberger, H., Kindt, R., Loo, J., Schmidt, M., Bognounou, F., *et al.* 2017. Spatially explicit multi-threat assessment of food tree species in Burkina Faso: A fine-scale approach. *PLOS ONE*, 12(9): e0184457. DOI: 10.1371/journal.pone.0184457

Galway, L.P., Acharya, Y. & Jones, A.D. 2018. Deforestation and child diet diversity: A geospatial analysis of 15 Sub-Saharan African countries. *Health & Place*, 51: 78–88. DOI: 10.1016/j.healthplace.2018.03.002

Gifford, J. 2016. How millennials (almost) killed the wine cork. The Atlantic. www.theatlantic.com/technology/archive/2016/02/wine-cork-comeback/470961/

Global Forest Watch. 2024. Global. In: Global Forest Watch. www.globalforestwatch.org/dashboards/global/

Gogoi, J., Sharma, M., Sharma, C.L. & Pangging, G. 2023. Market Survey of Wild Edible Plants Consumed by the Wancho Tribe in Longding District of Arunachal Pradesh.

Gómez-Baggethun, E., *et al.* 2013. Urban Ecosystem Services. In: T. Elmqvist, *et al.*, eds. Urbanization, biodiversity and ecosystem services: challenges and opportunities. Dordrecht, Springer. DOI: 10.1007/978-94-007-7088-1_11

Government of Canada. 2021. Statistical overview of the Canadian maple industry 2020. Ottawa, Canada, Agriculture and Agri-Food Canada.

Government of India. 2023. MSP for Minor Forest Produce (MFP). Tribal Co-Operative Marketing Development Federation of India Limited (TRIFED) https://trifed.tribal.gov.in/division/mfp-for-msp

Guissou, A.W.D.B., Parkouda, C., Vinceti, B., Traoré, E.M.A., Dao, A.S., Termote, C., Manica, M. & Savadogo, A. 2020. Variability of nutrients in Parkia biglobosa kernels from three geographical regions in Burkina Faso. *Journal of Food Science,* 14(3): 63–70.

Haq, S.M., Hassan, M., Jan, H.A., Al-Ghamdi, A.A., Ahmad, K. & Abbasi, A.M. 2022. Traditions for future cross-national food security. food and foraging practices among different native communities in the Western Himalayas. *Biology*, 11(3): 455. DOI: 10.3390/biology11030455

Hassan, Y. 2017. Gum Arabic in Sudan: an analysis of the value chain. Government of the Netherlands.

Hickey, G., Pouliot, M., Smith-Hall, C., Wunder, S. & Nielsen, M.R. 2016. Quantifying the economic contribution of wild food harvests to rural livelihoods: A global-comparative analysis. *Food Policy,* 62: 122–132. DOI: 10.1016/j.foodpol.2016.06.001

Homma, A.K.O. 2012. Plant extractivism or plantation: what is the best option for the Amazon? *Estudos Avançados*, 26(74): 167–186.

Ickowitz A., McMullin, S., Rosenstock, T., Dawson, I., Rowland, D., Powell, B., Mausch, K., Djoudi, H., Sunderland, T., Nurhasan, M., Novak, A., Gitz, V., Meybeck, A., Jamnadass, R., Guariguata, M.R., Termote, C. & Nasi, R. 2022. Transforming food systems with trees and forests. *Lancet Planet Health*, 6(7): e632–e639. DOI: 10.1016/S2542-5196(22)00091-2

Ickowitz, A., Powell, B., Salim, M.A. & Sunderland, T.C. 2014. Dietary quality and tree cover in Africa. *Global Environmental Change*, 24: 287–294.

Ickowitz, A., Rowland, D., Powell, B., Salim, M.A. & Sunderland, T. 2016. Forests, trees, and micronutrient-rich food consumption in Indonesia. *PLOS ONE*, 11(5): e0154139. DOI: 10.1371/journal.pone.0154139

Iddrisu, A.M., Didia, B. & Abdulai, A. 2017. Shea butter extraction technologies: current status and future perspective. *African Journal of Biochemical Research*, 13(2): 9–22.

International Bamboo and Rattan Organisation, INBAR. 2021. Bamboo and Rattan Update. 2(2):18 www.inbar.int/wp-content/uploads/2021/07/BRU-V2-I2.pdf

International Nut and Dried Fruit Council Foundation, INC. 2020. Nuts and dried fruits statistical yearbook 2019/2020. Reus, Spain, International Nut and Dried Fruit Council Foundation.

Ingram, V. 2014. Contribution to propositions for a normative and regulatory framework adapted to ensure legal access and sustainable exploitation of non-timber forest products in Cameroon. Zeist, The Netherlands and Yaoundé, Cameroon, Rapport final Ministère du Forêts et du Faune et GIZ.

Ingram, V., Ewane, M., Ndumbe, L.N. & Awono. A. 2017a. Challenges to governing sustainable forest food: Irvingia spp. from southern Cameroon. *Forest Policy and Economics*, 84:29-37.

Ingram, V., Vinceti, B. & van Vliet, N. 2017b. 'Wild plant and animal genetic resources.' in Danny Hunter, Luigi Guarino, Charles Spillane & Peter C. McKeown (eds.), Routledge handbook of agricultural biodiversity (Routledge).

Instituto Nacional de Estadística y Geografía, INEGI. 2019. Conociendo la industria del tequila y el mezcal. Comunicado de prensa núm. 342/19. www.inegi.org.mx/contenidos/saladeprensa/boletines/2019/OtrTemEcon/industriatequila.pdf

Intergovernmental Panel on Climate Change, IPCC. 2022. Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES. 2019. Global assessment report on biodiversity and ecosystem services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany, IPBES.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES. 2022. Thematic assessment report on the sustainable use of wild species. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. In: J.M. Fromentin, M.R. Emery, J. Donaldson, M.C. Danner, A. Hallosserie & D. Kieling, eds. Bonn, Germany, IPBES.

International Standard Industrial Classification of All Economic Activities, ISIC. n.d. Classification detail: ISIC, Rev. 4 – Code 0230. In: United Nations Statistics Division. https://unstats.un.org/unsd/classifications/Econ/Structure/Detail/EN/27/0230

Johnson, K.B., Jacob, A. & Brown, M.E. 2013. Forest cover associated with improved child health and nutrition: evidence from the Malawi Demographic and Health Survey and satellite data. *Global Health: Science and Practice,* 1(2), pp.237-248.

Krug, A.S., Drummond, E., Van Tassel, D.L. & Warschefsky, E.J. 2023. The next era of crop domestication starts now. *Proc Natl Acad Sci* 120(14): e2205769120. DOI: 10.1073/pnas.2205769120

Kuhnlein, H., Erasmus, B. & Spigelski, D. 2009. Indigenous Peoples' food systems: the many dimensions of culture, diversity and environment for nutrition and health. Rome, United Nations Food and Agriculture Organization and Centre for Indigenous Peoples' Nutrition and Environment (CINE).

Lachat, C., Raneri, J.E., Smith, K.W., Kolsteren, P., Van Damme, P., Verzelen, K., *et al.* 2018. Dietary species richness as a measure of food biodiversity and nutritional quality of diets. *Proc Natl Acad Sci*, 115(1): 127–132. DOI: 10.1073/pnas.1709194115

Laird S.A., Ingram V., Awono A. & Asaha S. 2020. Conservation and equity in the trade and use of biological and genetic resources - what does ABS bring to the table? Access and Benefit Sharing and the Case of Bush Mango (Irvingia spp.) in Cameroon. Voices for BioJustice, Policy Brief. www.voices4biojustice.org/wp-content/uploads/2017/12/Cameroon-Policy-Brief_2020.pdf

Laird, S.A., Awung, G.L. & Lysinge, R.J. 2007. Cocao farms in the Mount Cameroon region: biological and cultural diversity in local livelihoods. *Biodiversity Conservation,* 16(8): 2401–2427. DOI: 10.1007/s10531-007-9188-0

Laird, S.A., Awung G.L., Lysinge R.J. & Ndive E.L. 2011. The interweave of people and place: biocultural diversity in migrant and indigenous livelihoods around Mount Cameroon. *International Forestry Review,* 13(3): 275–293. DOI: 10.1505/146554811798293890

Leakey, R.R. 2019. A holistic approach to sustainable agriculture: trees, science and global society. In Agroforestry for sustainable agriculture (pp. 275-300). Burleigh Dodds Science Publishing.

Leakey, R.R., Weber, J.C., Page, T., Cornelius, J.P., Akinnifesi, F.K., Roshetko, J.M., Tchoundjeu, Z. & Jamnadass, R. 2012. Tree domestication in agroforestry: progress in the second decade (2003–2012). Advances in agroforestry – the future of global land use. Springer. pp.145–173.

Levis, C., Costa, F.R., Bongers, F., Peña-Claros, M., Clement, C.R., Junqueira, A.B., Neves, E.G., Tamanaha, E.K., Figueiredo, F.O., Salomão, R.P. & Castilho, C.V. 2017. Persistent effects of pre-Columbian plant domestication on Amazonian Forest composition. *Science*, 355(6328): 925–931.

Levis, C., Flores, B.M., Moreira, P.A., Luize, B.G., Alves, R.P., Franco-Moraes, J., Lins, J., Konings, E., Peña-Claros, M., Bongers, F. & Costa, F.R. 2018. How people domesticated Amazonian forests. *Frontiers in Ecology and Evolution,* 5: 171.

Li, X. & Siddique, K.H.M. 2018. Future Smart Food – Rediscovering hidden treasures of neglected and underutilized species for Zero Hunger in Asia. Bangkok, FAO.

Li, Y., Yao, J., Han, C., *et al.* 2016. Quercetin, inflammation and immunity. *Nutrients*, 8(3): 167. www.mdpi.com/2072-6643/8/3/167

Lompo, D., Vinceti, B., Gaisberger, H., Konrad, H., Duminil, J., Ouedraogo, M., Sina, S., & Geburek, T. 2017. Genetic conservation in Parkia biglobosa (Fabaceae: Mimosoideae) - what do we know? *Silvae Genetica,* 0(0), 1–8. DOI: 10.1515/sg-2017-0001

Lompo, D., Vinceti, B., Konrad, H., Duminil, J., & Geburek, T. 2020. Fine-scale spatial genetic structure, mating, and gene dispersal patterns in Parkia biglobosa populations with different levels of habitat fragmentation. *Applications in Plant Sciences,* 107(7), 1041–1053. DOI: 10.1002/ajb2.1504

Lompo, D., Vinceti, B., Konrad, H., Gaisberger, H., & Geburek, T. 2018. Phylogeography of African locust bean (Parkia biglobosa) reveals genetic divergence and spatially structured populations in West and Central Africa. *Journal of Heredity.* DOI: 10.1093/jhered/esy047

López Binnqüist, C., Contreras Jaimes, B. & Panzo Panzo, F. 2024. Milpa (Zea Mays). Traditional Foodways and NWFP Species Case Studies. www.peopleandplants.org/case-studies

López Diago, D. & García, N. 2021. Wild edible fruits of Colombia: diversity and use prospects. *Biota colombiana,* 22(2): 16–55. DOI: 10.21068/c2021.v22n02a02

Lovric, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P.J. & Mavsar, R. 2020. Non-wood forest products in Europe – A quantitative overview. *Forest Policy and Economics*, 116(2020): 102175.

Lovric, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P.J. & Mavsar, R. 2021. Collection and consumption of non-wood forest products in Europe. *Forestry: An International Journal of Forest Research*, 94(5): 757–770.

Łuczaj, Ł., Lamxay, V., Tongchan, K., Xayphakatsa, K., Phimmakong, K., Radavanh, S., Kanyasone, V., Pietras, M. & Karbarz, M. 2021. Wild food plants and fungi sold in the markets of Luang Prabang, Lao PDR. *Journal of Ethnobiology and Ethnomedicine,* 17(6): 1–27.

Maezumi, S.Y., Robinson, M., De Souza, J., Urrego, D.H., Schaan, D., Alves, D. & Iriarte, J. 2018. New insights from pre-Columbian land use and fire management in Amazonian dark earth forests. *Frontiers in Ecology and Evolution*, 6: 111.

Mansuri, S., Badawi, A., Kayaniyil, S., Cole, D.E., Harris, S.B., Mamakeesick, M., *et al.* 2016. Traditional foods and 25(OH)D concentrations in a subarctic first nations community. *Int J Circumpolar Health*, 75(1): 31956. DOI: 10.3402/ijch.v75.31956

Manzanilla, V., Kool, A., Nguyen Nhat, L., *et al.* 2018. Phylogenomics and barcoding of Panax: toward the identification of ginseng species. *BMC Evol Biol,* 18: 44. 10.1186/s12862-018-1160-y

Martínez de Arano, I., Maltoni S., Picardo A. & Mutke S. 2021. Non-wood forest products for people, nature and the green economy. Recommendations for policy priorities in Europe. A white paper based on lessons learned from around the Mediterranean. Barcelona, EFI and FAO.

Mishra, A., Swamy, S.L., Thakur, T.K., Bhat, R., Bijalwan, A. & Kumar, A. 2021. Use of wild edible plants: can they meet the dietary and nutritional needs of Indigenous communities in central India. *Foods*, 10(7): 1453. DOI: 10.3390/foods10071453

Muir, G.F., Sorrenti, S., Vantomme, P., Vidale, E. & Masiero, M. 2020. Into the wild: disentangling non-wood terms and definitions for improved forest statistics. *International Forestry Review,* 22(1): 101–119. www.ingentaconnect.com/contentone/cfa/ifr/2020/00000022/00000001/art00007

Narayanan, S. 2021. Food security from free collection of foods: Evidence from India. *Food Policy,* 100: 101998.

Ndumbe, N.L., Ingram, V., Enukwa, E.H. & Namuene, K.S. 2022. The socio-economic importance and sustainability of the major non-timber forest products collected in the south west and littoral regions of Cameroon. *Asian Journal of Research in Agriculture and Forestry,* 8(1): 20–36. DOI: 10.9734/ajraf/2022/v8i130145

Ogle, B.M., Hung, P.H. & Tuyet, H.T. 2001. Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety. *Asia Pacific Journal of Clinical Nutrition,* 10(1): 21–30.

Ojelel, S., Mucunguzi, P., Katuura, E., *et al.* 2019. Wild edible plants used by communities in and around selected forest reserves of Teso-Karamoja region, Uganda. *J Ethnobiology Ethnomedicine,* 15:3(2019). DOI: 10.1186/s13002-018-0278-8

Oslisly, R., White, L., Bentaleb, I., Favier, C., Fontugne, M., Gillet, J.F. & Sebag, D. 2013. Climatic and cultural changes in the west Congo Basin forests over the past 5000 years. *Phil. Trans. R. Soc.,* B 368: 20120304. DOI: 10.1098/rstb.2012.0304

Pehou, C., Djoudi, H., Vinceti, B., & Elias, M. 2020. Intersecting and dynamic gender rights to néré, a food tree species in Burkina Faso. *Journal of Rural Studies,* 76(February), 230–239. DOI: 10.1016/j.jrurstud.2020.02.011

Penafiel, D., Vanhove, W., Espinel, R.L. & Van Damme, P. 2019. Food biodiversity includes both locally cultivated and wild food species in Guasaganda, Central Ecuador. *Journal of Ethnic Foods,* 6: 1–13.

Powell, B., Thilsted, S.H., Ickowitz, A., *et al.* 2015. Improving diets with wild and cultivated biodiversity from across the landscape. *Food Sec.,* 7: 535–554. DOI: 10.1007/s12571-015-0466-5

Raneri, J.E., Boedecker, J., Fallas Conejo, D.A., Muir, G., Hanley-Cook, G. & Lachat, C. 2023. Can common dietary assessment methods be better designed to capture the nutritional contribution of neglected, forest, and wild foods to diets? *Front. Nutr.,* 10: 1186707. DOI: 10.3389/fnut.2023.1186707

Rasmussen, L.V., Fagan, M.E., Ickowitz, A., Wood, S.L., Kennedy, G., Powell, B., Baudron, F., Gergel, S., Jung, S., Smithwick, E.A. & Sunderland, T. 2020. Forest pattern, not just amount, influences dietary quality in five African countries. *Global Food Security,* 25: 100331.

Rasolofoson, R.A., Hanauer M.M., Pappinen A., Fisher B. & Richetts T.H. 2018. Impacts of forests on children's diet in rural areas across 27 developing countries. *Science Advances,* 4(8): 2853. DOI: 10.1126/sciadv.aat2853

Ray, A., Ray, R. & Sreevidya, E.A. 2020. How many wild edible plants do we eat—their diversity, use, and implications for sustainable food system: an exploratory analysis in India. *Frontiers in Sustainable Food Systems,* 4: (2020). DOI: 10.3389/fsufs.2020.00056

Reddy, K.N., Pattanaik, C., Reddy, C.S. & Raju V.S. 2007. Traditional knowledge on wild food plants in Andhra Pradesh. *Indian Journal of Traditional Knowledge,* 6(1): 223–229. https://nopr.niscpr.res.in/bitstream/123456789/910/1/IJTK%206(1)%20(2007)%20223-229.pdf

Richards, R. & Saastamoinen, O. 2010. NTFP policy, access to markets and labour issues in Finland: impacts of regionalization and globalization on the wild berry industry. In: S. Laird, J. McLain & R. Wynberg, eds. Wild product governance: finding policies that work for non-timber forest products. London, Earthscan.

Roche, M.L., Ambato, L., Sarsoza, J. & Kuhnlein, H.V. 2017. Mothers' groups enrich diet and culture through promoting traditional Quichua foods. *Matern Child Nutr.* 13: e12530. DOI: 10.1111/mcn.12530

Royal Botanic Gardens, Kew. 2020. State of the world's plants and fungi. A. Antonelli, C. Fry, R.J. Smith, M.S.J. Simmonds, P.J. Kersey, *et al.*, eds. Royal Botanic Gardens, Kew. DOI: 10.34885/172

Sardeshpande, M. & Shackleton, C.M. 2019. Wild edible fruits: a systematic review of an under-researched multifunctional NTFP. *Forests,* 10(467). DOI: 10.3390/f10060467

Schindler, C., Heral, E., Drinkwater, E., Timoshyna, A., Muir, G., Walter, S., Leaman, D.J. and Schippmann, U. 2022. Wild check – Assessing risks and opportunities of trade in wild plant ingredients. Rome, FAO. DOI: 10.4060/cb9267en

Shackleton C.M. & de Vos A. 2022. How many people globally actually use non-timber forest products? *Forest Policy and Economics,*135(5): 102659. DOI: 10.1016/j.forpol.2021.102659

Shackleton, S., Shackleton, C. & Shanley P., eds. 2011. Non-timber forest products in the global context. Amsterdam, Springer Verlag.

Shanley, P. & Gaia, G. 2002. Equitable ecology: collaborative learning for local benefit in eastern Amazonia. *Agricultural Systems,* 73: 83–97. DOI: 10.1016/S0308-521X(01)00101-9

Shanley, P., Pierce, A.R., Laird, S.A., López Binnqüist, C. & Guariguata, M.R. 2015. From lifelines to livelihoods: non-timber forest products into the twenty-first century. Tropical forestry handbook. Springer.

Shanley, P., Serra, M. & Medina, G., eds. 2010. Frutíferas e plantas uteis na vida Amazônica. Bogor, CIFOR/EMBRAPA. https://shorturl.at/FuQrK

Simonson, W., *et al.* 2018. Modelling biodiversity trends in the montado (wood pasture) landscapes of the Alentejo, Portugal. *Landscape Ecology*, 33: 811–827.

Smith, M.R., Singh, G.M., Mozaffarian, D. & Myers, S.S. 2015. Effects of decreases of animal pollinators on human nutrition and global health: a modelling analysis. *The Lancet,* 386(10007): 1964–1972.
Suwardi, A.B. & Navia, Z.I. 2022. Sustainable use and management of wild edible fruit plants: a case study in the Ulu Masen Protected Forest, West Aceh, *Indonesia. Journal of Sustainable Forestry,* 42(8): 811–830. DOI: 10.1080/10549811.2022.2123355
Termote, C., Odongo, N.O., Dreyer, B.S., Guissou, B., Parkouda, C. & Vinceti, B. 2020. Nutrient composition of Parkia biglobosa pulp, raw and fermented seeds: a systematic review. *Critical Reviews in Food Science and Nutrition,* 1–26. DOI: 10.1080/10408398.2020.1813072
The Insight Partners. 2021. Mezcal market size 2021 – industry size, share and analysis to 2027.
Thomson, L.A. & Evans, B. 2006. Canarium indicum var. indicum and C. harveyi (canarium nut). Traditional trees of Pacific Islands: their culture, environment and use. Traditional Tree Initiative.
Ticktin, T. & Shackleton, C. 2011. Harvesting non-timber forest products sustainably: opportunities and challenges. In: S. Shackleton, C. Shackleton & P. Shanley, eds. Non-timber forest products in the global context. Tropical Forestry, vol 7. Berlin, Springer. DOI: 10.1007/978-3-642-17983-9_7
Ulian, T., Diazgranados, M., Pironon, S., *et al.* 2020. Unlocking plant resources to support food security and promote sustainable agriculture. *Plants, People, Planet,* 2: 421–445. DOI: 10.1002/ppp3.10145
UN Comtrade. 2018. https://comtrade.un.org
UN Trade and Development, UNCTAD. 2018. Commodities at a glance: special issue on gum Arabic. In: UN Trade and Development. https://unctad.org/webflyer/commodities-glance-special-issue-gum-arabic
United States Department of Agriculture, USDA. 2021. New York ranked second in 2021 maple syrup production. Albany, New York, National Agricultural Statistics Service. www.nass.usda.gov/Statistics_by_State/New_York/Publications/Latest_Releases/2021/New%20York%20Maple%20Production%20Summary%202021.pdf
Van den Eynden, V., Cueva, E. & Cabrera, O. 2003. Wild foods from southern Ecuador. *Economic Botany,* 57(4): 576–603. DOI: 10.1663/0013-0001(2003)057[0576:WFFSE]2.0.CO;2
van der Wal, S. 2021. Brazil nuts: exploitative social and economic conditions in the Bolivian Amazon. In: Centre for Research on Multinational Corporations (SOMO). Amsterdam, The Netherlands. www.somo.nl/brazilnuts/
van Eerbeek, P. 2019. Thai local brokers in the Swedish berry industry: roles and positions across time and space. Sweden, Umeå University. Master's thesis.
Wallace, H., Hosseini Bai, S., Komolong, B., Nevenimo, T., Waai, C., Hannet, D., Hannet, G., Grant, E., Hodges, B., Kill, E., Randall, B., Carter, J., Jones, K., Simos, T. & John, C. 2021. Enhancing private sector-led development of the Canarium industry in PNG. ACIAR final report, project FST/2014/099. Bruce, ACT, Australian Centre for International Agricultural Research. https://aciar.gov.au/project/fst-2014-099
Walter, S. 2001. Non-wood forest products in Africa: A regional and national overview. Working paper FOPW/01/1. Rome, FAO.
Wardell, D.A., Tapsoba, A., Lovett, P.N., Zida, M., Rousseau, K., Gautier, D., Elias, M. & Bama, T. 2021. Shea (Vitellaria paradoxa C.F. Gaertn.) – the emergence of global production networks in Burkina Faso, 1960–2021. *International Forestry Review,* 23(4): 534–561. DOI: 10.1505/146554821834777189
Webb, P., Benton, T.G. & Beddington, J. 2020. The urgency of food system transformation is now irrefutable. *Nature Food,* 1: 584–585. DOI: 10.1038/s43016-020-00161-0
Wiersum, K. 2004. Forest gardens as an intermediate land-use system in the nature-culture continuum: characteristics and future potential. In P.K.R. Nair, M.R. Rao & L.E. Buck, eds. New vistas in agroforestry: a compendium for the 1st World Congress of Agroforestry. The Netherlands, Springer.
Wiersum, K., Ingram, V. & Ros-Tonen, M.A.F. 2014. 'Governing access to resources and markets in non-timber forest product chains', *Forests, Trees and Livelihoods,* 23: 6-18.
Workman, D. n.d. Top cork exporting countries. In: World's Top Exports. www.worldstopexports.com/top-cork-exporting-countries/
Wynberg, R. 2019. San and Khoi rooibos. Mail & Guardian, 1–7 November 2019. DOI: 10.13140/RG.2.2.17331.37920
Wynberg, R. 2020. Rooibos: a testing ground for access and benefit sharing in South Africa and beyond. Voices for BioJustice, Policy Brief. www.voices4biojustice.org/wp-content/uploads/2017/12/Rooibos-Policy-Brief_2020.pdf

For more information, please contact:
Forestry Division - Natural Resources and Sustainable Production
E-mail: NFO-Publications@fao.org
Web address: www.fao.org/forestry/en

Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-139226-3
9 789251 392263
CD2883EN/1/10.24